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## THE MIRROR OF CLEANLINESS:

On the construction and use  
of an environmental index for the Netherlands

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# THE MIRROR OF CLEANLINESS: ON THE CONSTRUCTION AND USE OF AN ENVIRONMENTAL INDEX FOR THE NETHERLANDS

by F.A.G. den Butter\*

## 1. Introduction

The almost compulsive drive for cleanliness has been noted as one of the mysteries of Dutch temperament. A Dutch housemaid washing the stoop, although to the casual eye to seem precious little to expunge, symbolizes this lust for cleanliness. The English historian Simon Schama (1987, p. 375) describes in his brilliant account of Dutch social and cultural history that 'no visitor to Holland failed to notice the pains that the Dutch take to keep their streets, their houses and themselves - though there is less unanimity about this - brilliantly clean. The spick-and-span towns shone from hours of tireless sweeping, scrubbing, scraping, burnishing, mopping, rubbing and washing.'

But that is history. Today the Netherlands is no clean country at all. Like most countries in the industrialized world it suffers from a severe pollution of the environment. There even are a number of reasons why the pollution problem is especially serious in the Netherlands. In the first place the density of population in the Netherlands is the highest of all European countries and hence is its urbanisation and its density of traffic. Secondly the Netherlands lies in the midst of a circle with a radius of only 500 kilometres, which has about 200 millions of inhabitants. Thirdly the Netherlands is the end basin of a number of large rivers which flow through industrialized areas and hence become much polluted. A major internal problem is the intensive use of agricultural land: the Netherlands utilizes the highest amount of fertilizer per acre of land amongst all agriculture countries. Therefore, in addition to the traditional drive for cleanliness, the Netherlands has a strong need for a stringent anti-pollution environmental policy because of its special topography and characteristics.

Anti-pollution policy measures have been announced in the so-called "National Environmental Policy Plan" (Nationaal Milieubeleidsplan, 1989), which should, 25 years from now, yield a sustainable economic development and a cleaned-up environment. However, there is no fixed general standard for the cleanliness that the plan aims at. With a sense of romanticism, the plan only formulates a large number of specific goals for the next 25 years. It states that the Dutch should be able in 2010 to swim in all inland lakes and

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rivers without becoming ill. Salmon should be able to breed in the upstream of the Rhine and Dutch Waddenzee should again provide a good habitat for the common seals.

Obviously the debate on the environmental policy needs a clear measure of pollution or "mirror of cleanliness". This environmental index, which summarizes all available data on the state of pollution and environmental damage, is to indicate to what extent the country has been polluted (Den Butter, 1990). Such index may be very helpful to the proponents of environmental policy in the economic debate, as it makes the environment a rival of other policy problems, such as unemployment, the government deficit, inflation, or disposable income, all of which are summarized in appealing indices.

This paper discusses the scope for the construction of an appropriate environmental index for the Netherlands and illustrates how it can be used in policy analysis. The next section surveys some general notions on the concept of the pollution index. Section 3 is on the relationship between the environment and welfare economics. Section 4 indicates how the price of the environment can be determined in the context of welfare economics using the concept of the pollution index. Section 5 gives some suggestions of how a pollution index can ideally be constructed if enough expert information and data were available. Section 6 illustrates some environmental indicators for which time series already are available but which are far from ideal. In section 7 these environmental indicators for the Netherlands are combined to a prototype of a mirror of cleanliness. However, the main lesson from this combination exercise is that we need much better data and more sophisticated combination techniques in order to arrive at an index of practical relevance. This and some other conclusions are drawn in section 8.

## 2. An index for environmental pollution

The need for summarizing the state of the environment in one index, or at least in a small number of appropriate indicators, has obtained general acceptance. Opschoor (1987) and the Social Economic Council (Sociaal Economische Raad, 1989) underline that such set of operational and quantitative indicators is essential from the standpoint of economic analysis in the Netherlands. However, the experts doubt about the possibility of combining these indicators to one overall index for the state of the environment. The argument is that it is far more difficult to add the great variety of aspects of pollution such as the extinction of animals and traffic noise than adding apples and pears which consumer theory has learned us to do.

Yet the impossibility of designing a perfect environmental index should not prevent us from constructing one which is less than perfect. In fact the same argument applies to calculating the national income, which has obtained general acceptance as a useful summary statistic for economic analysis. Moreover, a clear analogy exists between measuring the state of the environment and the trade cycle. The various trade cycle indices which are used in policy

analysis, combine a great variety of time series on economic phenomena which are seemingly incomparable.

The analogy which the trade cycle can be pursued by labelling the various ways in which the state of the environment is to be summarized in one index. The first form is an index just like the cyclical index, which summarizes the extent to which the country has been polluted, or inversely, has remained clean. We can think of an index with value 100 in the base year. However, it seems more appropriate to let the index express the extent to which the country is polluted in a direct way and use a scale which runs, say, from 0 to 100. This could be interpreted as the percentage of pollution of the environment. An index value of zero would in that case indicate the ideal state of Arcadia with no pollution at all, 5% would, for instance, be the goal to be reached in future, 20% as a critical value above which human life becomes unbearable and 100% as the level of pollution which destroys all life on earth.

The second form of appearance of the environmental index is analogous to the leading indicator in cyclical analysis. This kind of *environmental barometer* would provide a prediction of the future state of the environment. The need for such an index is obvious as it takes generally a long time for a policy measure to have a final effect on the state of the environment (see e.g. the long lags between reductions of sulphite emissions and the decrease of acidification of surface water).

As alternative to the environmental index and barometer, ecologists usually express the need for an index as a kind of Plimsoll-line. It is a maximum utilisation rate for the various elements of the environment: above this limit nature loses its self-regenerating character and the environmental situation becomes unstable. Although this Plimsoll-line is quite easy to establish for a ship, drawing the line for the environment appears to be very difficult. Whereas the environmental index and barometer have a mere descriptive character, the Plimsoll-line is used in a normative sense: pollution is not allowed to surpass its critical value.

The environmental index is crucial for making the concept of sustainable economic growth operational. In this context sustainable economic growth can be defined as equilibrium growth at a constant value of the environmental index. Obviously for this definition of sustainability no monetisation of the environmental capital is needed. Therefore there is no necessity to calculate a green GNP, which is the actual GNP from the National Accounts corrected for the users cost of the environmental capital which that growth involves. As a matter of fact such correction of the GNP may very well obscure the question whether the growth has been sustainable or not. A 3 % growth of the green GNP can for instance either be the result of a 5% growth of actual GNP and 2% additional pollution or a 1% growth of actual GNP and a reduction of the level of environmental damage with 2 %. Of course calculation of both the actual GNP and green GNP implicitly defines an environmental index. However, this monetized index will only be equal to the 'true' index in case the (implicit or explicit) price determination of the environment has been fully correct. In practice such price formation which fully reflects environmental damage seems impossible.

Therefore a non-monetized index has the advantage over a monetized index that a serious type of pollution which is relatively cheap to redress, because it carries a large weight in the overall environmental index, will be reduced first.

### 3. Environment and welfare

The relation between pollution and welfare takes a prominent place in the economic debate on the environment (see Opschoor, 1990 and Heertje, 1990). From the viewpoint of social welfare Heertje regards the environment, or more broadly formulated, the nature, as a consumer product because refraining from the destruction of nature such as woods, meadows, lakes, seashores, with all their living plants and animals, directly satisfies the needs of human beings at present and in the future. That's why Heertje advocates to include the amount of unspoiled nature in the social welfare function. Economic policy should be directed at a welfare growth in which the environment carries a large weight. Moreover Opschoor argues to include environment not only in the welfare function, but also in the production function.

In the 1950's the Social Economic Council has formulated 5 goals for macroeconomic policy in the Netherlands, namely low unemployment, price stability, steady economic growth, balance of payments equilibrium and a reasonable income distribution (see Schouten, 1985, for a survey). The arguments above imply that the social welfare function defined by these 5 policy goals, has to be extended with a 6th goal: the environment. Obviously the 5 traditional policy goals can be quantified in simple summary statistics. These numbers carry a large weight in actual policy. The dramatic increase of unemployment has contributed to the consensus on the policy of wage restraint in order to enhance employment. The increase of the government deficit, which is not on the original list of policy goals of the Social Economic Council, has obtained a large publicity and attention of policy makers in the 1980's as well. In that case there also is one number which directly reflects policy effectiveness.

The environment will only be able to compete with these traditional policy goals in case it can be summarized in one number in the same appealing way. That is a major reason why an environmental index is needed. The index may show the success or failure of the proposed measures of environmental policy. The policy goals with respect to the environment can be formalized, just as is the case for the budgetary policy and the employment policy, in the so called "Government Agreement", when the new government is formed. When, for instance at the date of the formation of the government pollution has reached the level of say 15%, the government could aim at a reduction in the next 4 years to a level of say 10 %. Anyhow the Prime-Minister could promise to resign in case his government does not succeed to reduce the level of pollution and bring it under 15.

It should be noted that the Social Economic Council did not completely disregard the environment when discussing the economic policy goals. In the 1960's an ambiguous

formulation combined environment and economic growth as policy goals. In the Netherlands the publication of the Meadows Report for the Club of Rome Project in 1972 caused, unlike in most other countries, a temporary upgrading of the role of the environment in economic thinking. However, the result was that in the 1970's the environment disappeared as policy goal and shifted to be a (necessary) condition for economic policy. Nowadays the Social Economic Council argues that the goal of maintaining ecological equilibrium has a higher ranking than the 5 traditional goals of macroeconomic policy. However, in practice this high rank of the environment is similar to that of the ceremonial head of state: the position is not really powerful. A better position for the environment is, as argued before, to include it in the welfare function and to let the trade-offs with regard to the other policy goals be determined openly in the policy process.

The inclusion of the environment in the social welfare function still poses a number of intellectual problems. The repair of environmental damage may take a long time, and sometimes the damage cannot be repaired at all. That's why the environment, as a part of social welfare, affects many generations. The present environmental policy is not only directed at the welfare of our own generation, but also at the welfare of future generations. However, we do not know the trade-offs of these future generations with respect to environment and other policy goals. A solution for this problem is the so called identification principle, according to which the present generation identifies the preferences of the future generation to its own. The next question is what discount rate we should use in the resulting optimization problem for the welfare of future generations. The discount rate commonly used in such circumstances reflects the time preference. The environmental problems, however, have such a long horizon, that the market interest rate as discount rate would very poorly serve the interests of future generations. For that reason some economists prefer a discount rate of zero in this case. That solution does invoke another problem because it is inconsistent not to discount the assets, while the liabilities are to be discounted at the normal market rate, which should be paid for the environmental investments made for future generations.

#### 4. The price of the environment

A major question in the economic debate of the environment is: 'Who determines the price of the environment and who pays for it?' This question can be answered in the context of welfare theory, as we have seen in the previous section, that the environment, or nature, can be considered both as a consumption good and the production factor. In principle price formation of the environment can be treated in an analogous way as the price formation of exhaustible and partly renewable natural resources. When exhaustion increases and the stock of environment becomes scarce, its price will rise. This makes the use of alternatives more profitable and automatically sets a limit to exhaustion. However, the self-regenerating power of the environment, which disappears when a certain limit has been surpassed, complicates the price formation process.

Now the vital question is whether we can leave this price determination process to the market, as classical welfare theory would prescribe, or whether the price of the environment should be determined in a more autocratic way. When full information were available on the remaining stock of the environment and on its self-regenerating power, and when the interests of the future generations would be fully taken into an account, no much objection can be made to let in the price of the environment be determined by the market. Obviously these conditions do not hold, as our knowledge on the environment and the altruism towards future generations is rather limited. The impression is that at this moment the market price of the environment is much too low. Still a large gap exists between the actual utilisation price of the environment and its social or welfare costs. Therefore, from the welfare point of view, the use of the environment is far from optimal. For that reason it does not seem wise to let the market determine the price of the environment at this moment.

But who else determines that price? Maybe those who enjoy nature as a consumption good. Such price determination is possible using questionnaires, which, for instance, ask the visitors of a recreation area how much they would be willing to pay for the song of the nightingale, or the price can be determined by revealed preferences in this respect (see Folmer, 1990, for a survey of methods to determine the price of the environment). However, this leaves the determination of the price of the environment completely to the specific preferences of nature lovers. It does not warrant the interests of future generations either. Moreover the nature lovers will overvalue the spectacular but exterior aspects of natural beauty and will undervalue those hidden aspects which are vital for ecological equilibrium.

Therefore I see no other possibility than to let the price of the environment be determined by experts. This price determination can, as we shall see, proceed along the same lines as the construction of an environmental index, which is based on expert opinions. It should be noted that this form of interventionist price formation does not exclude the role of the market when the prices are to be paid. On the contrary, it seems desirable that once the price of the environment has been determined, the goals of the environmental policy should be reached by the use of market conforming instruments, such as taxes or transferable pollution rights, and not by quota or prohibition orders.

##### 5. The construction of an environmental index

The state of the environment can be characterized by a large number of aspects, which are again quantifiable in many ways. Such quantification is relatively easy for those aspects which play an important part in the discussions on the National Environmental Policy Plan, such as the sulphite and nitrogen emissions which cause acidification, the emission of CFC's, pollution of surface water, etc.. However, aspects which are less easily quantifiable such as noisiness, air pollution, actual pollution of the soil, threat of the greenhouse effect, the extent of disruption of ecosystems, the extinction of wild life etc. should also have their place in the overall pollution index.



For the construction of a proper environmental index firstly all available time series information on the various aspects of the environmental problem should be collected, and when information is not available on important aspects, action should be taken to set up indicators for that aspect. In this respect lot of work has been done recently in the field of so called sustainability indicators. However, some of these indicators have a prospective character, and it would be appropriate to include them in an environmental barometer, but not so much in an environmental index which solely describes the present state of the environment.

In spite of this restriction a lot of indicators will, in principle, be adequate to be included in the Dutch environmental index. All these measures of various aspects of the environment should be grouped and weighted according to their importance. Here the experts enter the stage. The environmental experts - biologists, ecologists, etc.- should determine the trade-offs with respect to these various environmental aspects.

**Chart 1The 'Amoebe approach' for the construction of an ecological Dow Jones index for pollution of the North Sea**

Source: Ten Brink (1989)

An interesting example of such weighting exercise with respect to one aspect of pollution is the 'Amoebe-approach' by Ten Brink (1989) of the Tidal Waters division of the Dutch Institute of "Rijkswaterstaat". The Amoebe-approach yields, as Ten Brink calls it, an ecological Dow Jones index for the ecosystem of the North Sea. This approach is based on an estimation of the numbers of 32 plant and animals species in the Dutch part of the continental shelf. These 32 species are, as far as possible, a cross section of the entire system. The numbers of these species in 1930 act as reference. For that year, which is considered to represent more or less the Arcadic situation of no pollution, the numbers for all species considered are standardized to lie on a unit circle. When the actual numbers of these species are depicted we get an image which looks like an amoeba: some of these species, such as the common seal, the bottlenose dolphin and the cockle beds, have become much smaller in number as compared to 1930 where others such as total algae and the oystercatcher have become much more numerous as compared to the reference year (see chart 1). For the construction of the index the percentage change of the actual situation as compared to the reference situation is calculated for each species. The differences of these percentages from 100 are, in absolute values, summed over the 32 species, which yields the ecological Dow Jones. Hence, when the shape of the amoeba approaches the circle, the ecological Dow Jones index decreases, indicating less pollution of the North Sea. In this way a policy goal for the reduction of pollution can also be depicted in the shape of an amoeba, with a corresponding value for the ecological Dow Jones index, which should of course not necessarily be equal to the Arcadic situation of the circle yielding an index value of zero.

Consequently Ten Brink has implicitly valued the trade off between, for instance, seals and cockle beds. In spite of the public interest for seals, an increase of the number of seals with 10%-points as compared to the reference situation is valued as much as a 10%-points increase of the number of cockle beds. However, when other biologists would not agree with these implicitly determined trade-offs, it would as yet be possible to weight the conflicting opinions and come to one index number for the pollution of the North Sea using the Amoebe-approach.

The next step in the construction of the environmental index is to combine all these ecological Dow Jones indices, which describe just one aspect of pollution, to one index value, again using expert opinions for the determination of weights. This index number would mirror the general situation of the environment in the Netherlands and would therefore indicate the extent to which the country has been polluted.

As mentioned before, the concept of sustainable economic development can now be made operational by defining it as development under the condition of a constant overall pollution index. However, this definition does not determine the level of pollution at which the sustainable development has to take place. Usually environmental specialists consider a more restricted definition of sustainable development. Their definition often includes explicit norms for a reduction of pollution. For example, one of the norms for ecological sustainability of the North Sea is a reduction of pollution so that the amoeba comes to a shape where the number of each species lies within the 75%- 125% interval around the

reference value. For that reason it is essential to dispose of reference values for all component parts of the combined index which describes sustainable development from an ecological or an economic point of view. Moreover, for each component part of the index, critical load values should be determined, which may not be surpassed because otherwise nature will completely lose its regenerating power. In this way, elements of the Plimsoll-line can be introduced in the index.

When the environmental experts have established the various trade-offs between the component parts of the index, politicians should determine the trade-offs between the pollution of the environment and the other policy goals in the macroeconomic welfare function. Thus politicians are asked to value the environment against, for instance, economic growth, unemployment and inflation. The traditional theory of economic policy assumes that politicians are able to assess, for instance, the trade-off between inflation and unemployment and can quantify how many percentage points of additional inflation they are willing to pay for one percentage point reduction of unemployment. Equally they should be able to make their preference for a clean environment explicit by expressing how much growth they want to give up for a reduction of the environmental index with, say, 10 points. Once these policy choices have been made explicit, economists are able to calculate the shadow price of the environment.

However, such perfect quantification is still an utopia. At present there is an enormous lack of appropriate time series data on all specific aspects of pollution and there is no consensus amongst experts on the trade-offs between these aspects. Therefore we will dispense with the idea of constructing an ideal index and concentrate on some scarce time series information on pollution which is readily available.

## 6. Environmental indicators

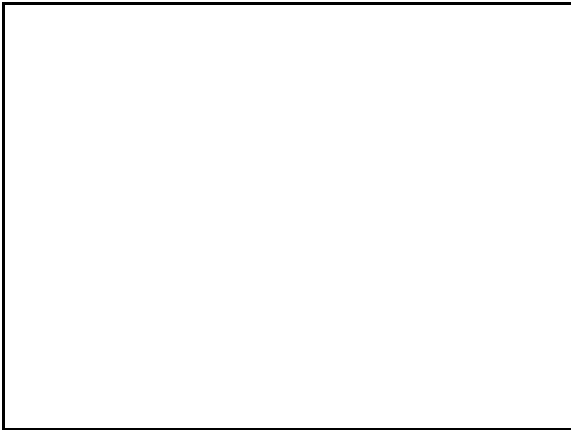
Although a lot of environmental data have been collected in the Netherlands, remarkably few time series information is available which can be regarded as overall indicators for the state of the environment. In an survey of measures of cleanliness, which would appropriately cover most aspects of environmental pollution, the Institute for Environmental Studies of the Free University (IvM) (see Vos *et al.*, 1985, 1986) gives a list of 15 prospective indicators. For the indicators to be included in an overall index reliable time series should exist on a yearly basis over a period of say 20 years. However, for the majority of the indicators on the IvM list only data for one specific year are available, or at most for 2 or 3 years. Opschoor (1990, page 32) presents a qualitative survey of the state of the environment using time series data collected by the CBS for 26 indicators, which are associated with environmental pollution. However, these indicators cover only some aspects of the environment.

Therefore, at present the construction of an environmental index for the Netherlands, albeit a prototype, is severely hampered by the lack of appropriate data. Yet, in order to show how the various indicators can be combined into one index, we have selected from public statisti-

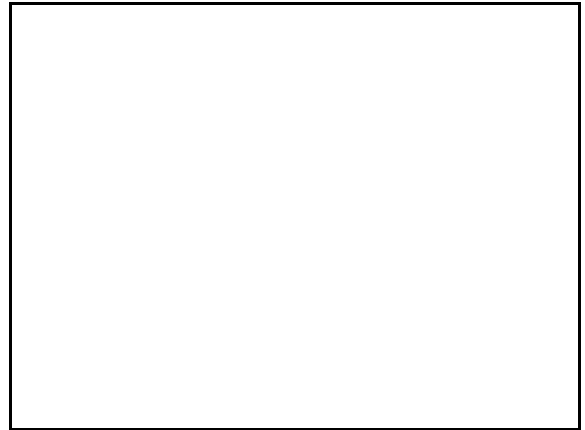
cal sources a number of annual time series data, which are promptly available and which contain enough information in order to enable time series analysis. The data used in this study are depicted in chart 2.

**Chart 2.Environmental indicators for the Netherlands**

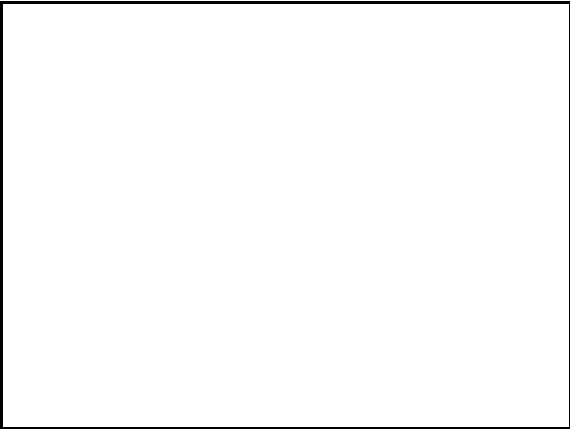
Chloride load of the Rhine



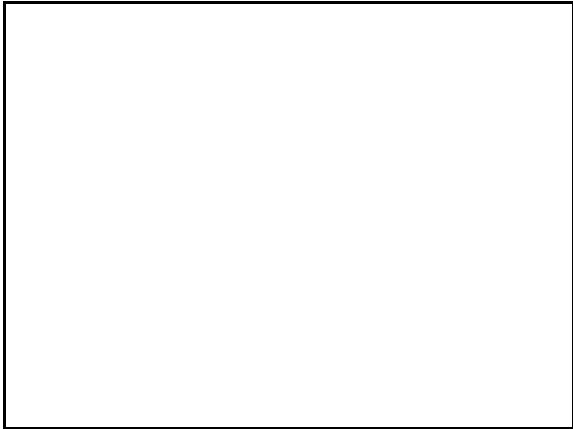
Manure production



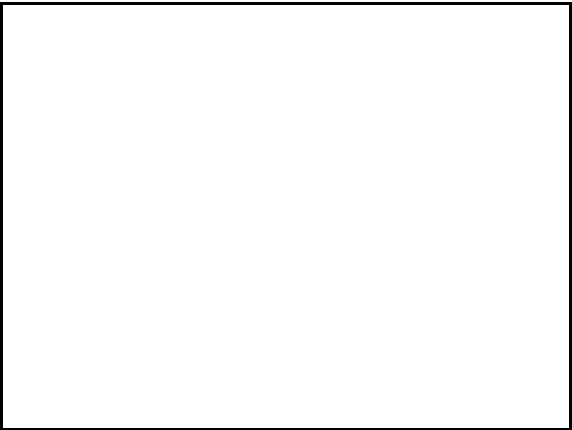
Use of fertiliser



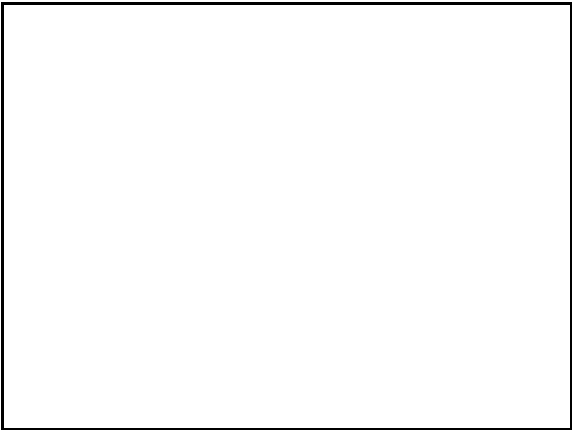
Domestic and industrial garbage



Common seals in the "Waddenzee"



Emission of mobile sources



Total mobility



Oxygen drainage of households on surface waters



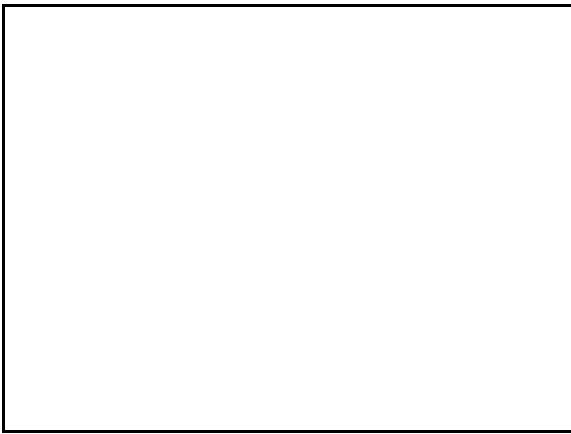
Acidity of rainfall



Vitality of woods



Use of land for industry and buildings



We appreciate that some of these indicators of chart 2 represent aspects which can be directly linked with pollution, (chloride load of the Rhine, domestic and industrial garbage, common seals in the Waddenzee, drainage of oxygen by households on surface waters, acidity of rainfall and vitality of woods), while the other indicators (manure production, use of fertilizer, total mobility, and use of land for industry and buildings) are related to pollution in more indirect ways. Moreover, some of these indicators relate to a large extent to imported pollution (acidity of rainfall, number of seals, vitality of woods, and, in particular, chloride load of the Rhine), whereas the others mainly measure domestic pollution. It should be noted that, with the exception of common seals in the Waddenzee and the vitality of woods, a higher level of the indicator represents a higher level of pollution. In order to standardize the series in this respect, the series of common seals in the Waddenzee has been inverted in the combination exercise of the next section (due to a lack of observations the series on vitality of woods is not used in that exercise).



Chart 2 shows that 5 series (manure production, use of fertilizer, domestic and industrial garbage, total mobility and use of land for industry and buildings) exhibit a clear positive trend over the reference period 1970-1988 which would indicate an increase of pollution. On the other hand the emission of mobile sources and the oxygen drainage of households on surface water show a clear downward trend. Although in selecting these indicators we have tried to represent different aspects of pollution with each indicator, we have both included a series on emission of mobile sources and on total mobility, because the first series only indicates a very specific part of the pollution caused by traffic, whereas total mobility includes all external costs. The data on acidity of rainfall appear to be very erratic and therefore do not provide a reliable indicator. We have left this series out of our analysis. For the vitality of woods (see Ministerie van Landbouw, Natuurbeheer en Visserij, 1990), which can be regarded as a good example of an indicator to be included in the environmental index, unfortunately only a few observations are available. The series for the chloride load of the Rhine and the common seals of the Waddenzee do not exhibit a clear trend over the whole reference period. The low number of common seals in the Waddenzee in 1988 is due to an infection disease which decimated the seals in that year.

In the economic debate on the environment pollution is often associated with economic growth. In order to illustrate a possible link between growth and pollution table 1 gives the correlations of the selected environmental indicators and the volume of national product. Obviously all indicators with an upward trend are positively correlated with national product, and inversely the indicators with a clear downward trend show a negative correlation.

**Table 1. Correlation of environmental indicators and national income**

Indicator	Correlation coefficient
Chloride load of the Rhine	0.41
Manure	0.95
Fertiliser	0.86
Garbage	0.95
Common seals	0.12
Emission of mobile sources	-0.91
Mobility	0.98
Oxygen on surface waters	-0.86
Acidity of rainfall	0.72
Vitality of woods	-0.66
Land for industry and buildings	0.94

## 7. Combining environmental indicators.

This section illustrates some features of the methodology for the construction of an overall environmental index outlined in section 5 and problems associated with it, using the time

series data on the indicators discussed above. The obvious analogy with the construction of a cyclical indicator which provides a measure for the state of the trade cycle, has already been noted. In trade cycle analysis the technique of *principal components* is often used as a method for integrating and summarising information from various data sources. Principal component analysis, which is related to factor analysis, tries to condense the information content of time series into a limited number of components with the minimum loss of information<sup>1</sup>. Besides cyclical analysis this technique is, for instance, used by Fase (1973, 1976) for the identification of common patterns in interest rate movements. More specifically principal component analysis aims at distracting shared but unobserved factors underlying the original data. Whereas the input data may be correlated, the principal components are, by definition, orthogonal. The principal components are arranged in the order of size so that the first principal component explains the highest amount of variance in the original data. In other words, the first principal component can be regarded as an unobserved dependent variable in a regression equation where the indicators act as explanatory variables and in which the data for this unobserved dependent variable are constructed in such a way that the regression has the highest explanatory power (highest  $R^2$ ). Technically the principal components are derived by calculating latent roots of the standardized sample matrix. The first principal component is associated with the highest latent root, the second principal component with the second highest root, etc. etc..

In first instance we tried to compute the principal components for all indicators described in the previous section for which data are available over the whole reference period 1970-1988. Hence we excluded the drainage of oxygen, the acidity of rainfall and the vitality of woods from our analysis. However, for the interpretation of the principal components it is necessary that in case of a specific interpretation of the underlying indicators - such as in this case where higher values of the indicators are associated with more pollution -, that all indicators point more or less in the same direction. This is not the case with the emission of mobile sources which shows a downward trend, while the majority of the other series has an upward trend. This results in a high negative weight for the emission of mobile sources in the first principal component, so that this component can no longer be interpreted as an index of pollution because less emission of mobile sources causes a rise of the value of the pollution index.

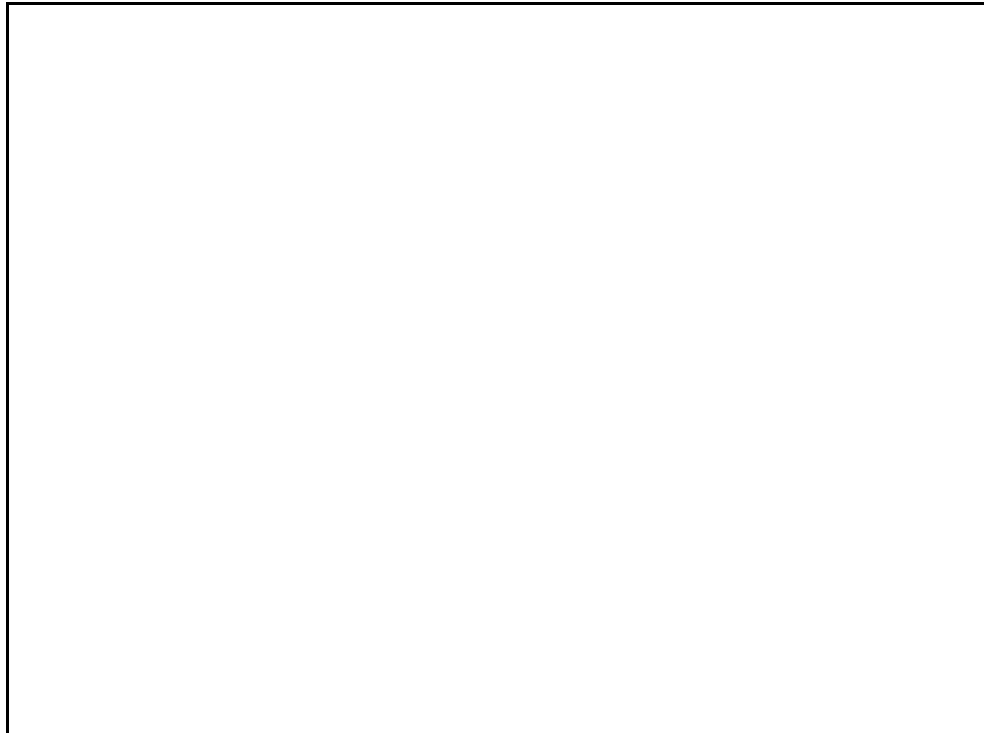
Therefore we have left the emission of mobile sources out of the calculation, and computed the principal components for the remaining 7 indicators. The results of table 2 show that the first component now explains almost 70% of the total variance of the indicators, whereas the second component yields an additional explanation of about 18%. Hence the first two components adequately summarise the information content of the indicators under review. As shown in chart 3, the first principal component exhibits a clear upward trend. Therefore

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<sup>1</sup> Unlike factor analysis, principal component analysis is a method of descriptive statistics, which is not based on formal statistical theory.

it can be associated with economic growth represented by the volume of the national product which is also depicted in the chart.

**Chart 3**First principal component of 7 indicators, and national product



**Table 2**Two largest latent roots and percentages of variation for 7 indicators

Component	Latent root	% of variance	cumulative %
1	4.89	69.8	69.8
2	1.24	17.6	87.5

However, the interpretation of the second principal component is far less unambiguous. This is illustrated in table 3, which gives the weights or so-called factor loadings for the 7 indicators in the first and second principal components. The second principal component appears to be highly correlated with the number of common seals in the Waddenzee, which shows no correlation with the first component. It looks like an interesting result as we could identify the second principal component as a (policy induced) deflection of pollution from

economic growth. However, the other indicator which is not highly correlated with the first component, the chloride load of the Rhine, obtains a negative weight in the second component. That is what makes the interpretation of this component impossible. It also shows that we should be very cautious to designate the number of seals as a major indicator of overall pollution in the Netherlands, although at first sight it seems a neat series for this purpose.

**Table 3** Factor loadings for 7 indicators (after varimax rotation)

Indicator	Component 1	Component 2
Chloride load of the Rhine	0.50	0.61
Manure	0.96	0.11
Fertiliser	0.87	0.34
Garbage	0.96	-0.07
Common seals	0.13	-0.91
Mobility	0.98	0.01
Land for industry and buildings	0.97	0.09

As an alternative for the principal component analysis we have combined the indicators by calculating simple index values. For each of the 8 series, for which data are available over the whole reference period, an index has been constructed with 1970 = 1. Chart 4 shows both the arithmetic and the geometric mean index for these 8 indicators. It should be noted that in this combined index no weights have been used and hence that all indicators are valued equally in the index. The chart indicates that the geometric mean index assesses the increase of pollution over the reference period as somewhat larger than the arithmetic mean. However, the combined index appears to be not much sensitive to that specification change.

In addition to these simple indices we consider the following more flexible form for combining the indicators:

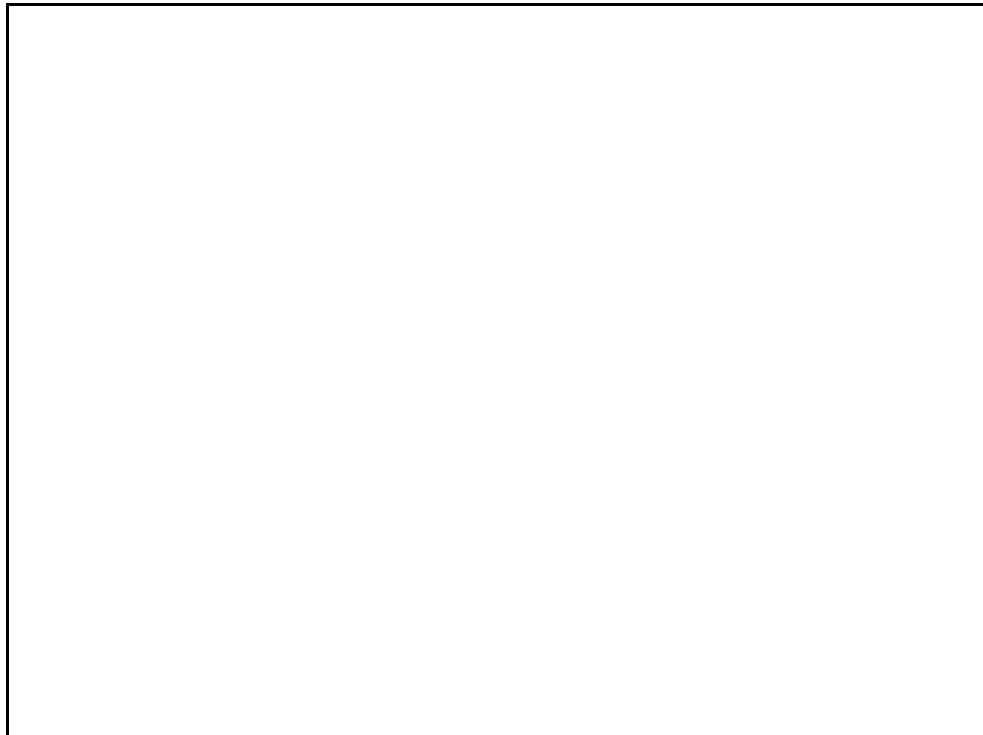
$$I_t = (\sum x_{it}^\rho)^{1/\rho}$$

with  $I_t$  the index value in year  $t$  and  $x_{it}$  the value of the  $i$ th indicator in year  $t$ , and

where the index  $I_t$  is normalised in such a way that  $I_{1970} = 1$ . This specification resembles a CES-function and parameter  $\rho$  in the formula indicates the extent of "substitution" between the indicators. In case  $\rho = 1$  we have the arithmetic mean, while for large values of  $\rho$  the indicator with the highest value obtains the largest weight. In this way the construction of the index allows for critical load effects where high levels of pollution are associated with large weights (see also Ott, 1978, p. 341, who calls it a root-sum-power damage function). Chart 5 depicts three different indices, constructed by means of the CES-function, with

respective values of  $\rho$  of 1, 5, and 50. The chart shows that the index with a high value of  $\rho$  exhibits relative strong fluctuations.

**Chart 4 Geometric and arithmetic mean index of 8 indicators**



+ arithmetic mean                      □ geometric mean

Finally table 4 gives the correlation of the combined indices calculated above, with economic growth and with the other indicators for environmental pollution. The table shows that the arithmetic mean index (= CES with  $\rho = 1$ ) and the geometric mean index are highly correlated with economic growth and hence with the first principal component of the 7 indicators. The correlation between the CES index with  $\rho = 50$  and economic growth is less sizeable. Now we see a rather high correlation with the number of seals, which is, however, to a large extent due to the hugh decrease of the number of seals in 1988 because of the infection disease. Obviously it does not reflect a sudden increase in actual pollution. This incident exemplifies that in constructing an environmental index we should always monitor whether the indicators which underlie the combined index, are still appropriate for the purpose. A similar incident happened to the construction of the cyclical index after the stock market crash of October 1987 (black monday). In that case a cyclical indicator which included the stock exchange index as component, suggested a sudden deterioration of the business cycle. However, actually no such deterioration took place. Therefore the stock exchange index had to be removed from the cyclical indicator.

**Chart 5** Mean index of 8 indicators, constructed by means of CES-function  
( $\rho = 1$ ,  $\rho = 5$  and  $\rho = 50$ )



#### 8. Conclusions.

The environment is still much understated in the macro economic debate. The main reason is the lack of a clear index which mirrors the state of the environment, and in terms of which policy goals can be formulated in the same way as goals for reducing unemployment or for reducing the government deficit. This paper advocated construction of such index or "mirror of cleanliness" which can be used in policy analysis. Moreover, the index can be used for quantification of the environmental policy in macro-economic models (see e.g. Den Hartog and Maas, 1990, Mulder, 1990).

**Table 4**Correlation of the mean indices of the 8 indicators with other indicators

Indicator	Arithmetic mean	Geometric mean	CES ( $\rho=1$ )	CES ( $\rho=50$ )
National product	0.91	0.89	0.91	0.54
Acidity of rainfall	-0.15	-0.33	-0.15	0.06
Vitality of woods	0.14	0.29	0.14	-0.03
Common seals (inv.)	0.50	0.48	0.50	0.86
First principal component of 6 indicators	0.92	0.91	0.92	0.50

The construction of an environmental index is by no means an easy task, and many experts will even consider it an impossible task. Such is certainly true for an ideal index, on which all agree. Yet for the construction of a less than ideal index, as outlined in section 5, we still need a lot of information: time series on various aspects of pollution and experts' opinions on how to value these aspects in relation to each other. Moreover, our description of how the index should be constructed, abstracts from the different dimensions both in time (long lags between policy measures and final effects on the environment) and space (local, regional, national, worldwide scale of the problem, import and export of pollution to and from abroad). The spatial aspect of the environmental index portrays, in the case of a small, open economy, another aspect of its possible use in policy analysis. When similar indices are constructed for several neighbouring countries, regression and/or causality analysis may reveal how much domestic pollution can be attributed to pollution abroad, and to what extent a reduction of the level of pollution can be induced by domestic environmental policy measures. In this way, the pollution indices and the resulting environmental "trade balances" may constitute a basis for international negotiations on worldwide policy measures to deflect pollution.

In order to illustrate techniques for the construction of an environmental index, and problems associated with it, the paper presents calculations for the prototype of such an index, based on the scantily available time series information for the Netherlands. The application of principal components analysis, which is done by analogy of the construction of a trade cycle index, is hampered by the fact that some of the pollution indicators exhibit opposite trends. As an alternative unweighed indices can be used, but we should be aware that these indices are quite sensitive to the specification of the combination formula. Moreover, the indicators on which information is available by no means cover all aspects of pollution in the Netherlands. Yet we see that the majority of the indices constructed by us, still show an apparent correlation with national product. It does not imply that deflecting economic growth is a necessary condition for our environment to become less polluted, but it does imply that stringent policy measures are needed to refrain pollution from running parallel to economic growth (see also Pen, 1990). The main conclusion of this paper is,

however, that much more time series data and experts' opinions on trade-offs are needed for the construction of a mirror of cleanliness, in order to grant it just some practical relevance.

#### References

**Brink, B.J.E. ten**, 1989, Amoebe Approach; a Method for Description and Assessment of Ecosystems, Summary Poster, 3rd North Sea Seminar 1989, Distress Signals, Rotterdam.

**Butter, F.A.G. den**, 1990, Op zoek naar een milieuspiegel: hoe vuil is Nederland?, Economisch Statistische Berichten, 75, pp. 196-199.

**Fase, M.M.G.**, 1973, A principal components analysis of market interest rates in the Netherlands, 1962-1970, European Economic Review, 4, pp. 107-134.

**Fase, M.M.G.**, 1976, The interdependence of short-term interest rates in the major financial centres of the world, KYKLOS, 29, pp. 63-96.

**Folmer, H.**, 1990, De prijs van het milieu, in Geïntegreerd Milieuonderzoek (Koninklijke Nederlandse Academie van Wetenschappen, Amsterdam), pp. 41-55.

**Hartog, H. den, and R.J.M. Maas**, 1990, Een duurzame economische ontwikkeling: macro-economische aspecten van een prioriteit voor het milieu, in P. Nijkamp and H. Verbruggen (eds.), Het Nederlands Milieu in de Europese Ruimte, Preadviezen van de Koninklijke Vereniging voor de Staathuishoudkunde 1990 (Stenfert Kroese, Leiden), pp. 77-126.

**Heertje, A.**, 1990, Groei en krimp bij duurzame ontwikkeling: welke kennis is nodig?, in P. Nijkamp and H. Verbruggen (eds.), Het Nederlands Milieu in de Europese Ruimte, Preadviezen van de Koninklijke Vereniging voor de Staathuishoudkunde 1990 (Stenfert Kroese, Leiden), pp. 43-75.

**Ministerie van Landbouw, Natuurbeheer en Visserij**, 1990, De Vitaliteit van het Nederlandse Bos 8, Verslag van de landelijke Vitaliteitsinventarisatie 1990, Directie Bos- en Landschapsbouw, Rapport 1990-19.

**Mulder, R.J.**, 1990, Milieubeleid en macro-economie, Maandschrift Economie, 54, pp. 347-363.

**Nationaal Milieubeleidsplan**, 1989 (Tweede Kamer, 21 137 nrs.1-2) (SDU Uitgeverij,'s-Gravenhage).

**Opschoor, J.B.**, 1987, Duurzame ontwikkeling: een pleidooi voor herverdeling en herregulering, in A. van Amstel and H.Jansen (eds.): Environment and Development the Year 2000 and Beyond (IvM, Amsterdam), pp. 71-81.



**Opschoor, J.B.**, 1990, Ecologisch duurzame economische ontwikkeling: een theoretisch idee en een weerbarstige praktijk, in P. Nijkamp and H. Verbruggen (eds.), Het Nederlands Milieu in de Europese Ruimte, Preadviezen van de Koninklijke Vereniging voor de Staathuishoudkunde 1990 (Stenfert Kroese, Leiden), pp. 7-41.

**Ott, W.R.**, 1978, Environmental Indices: Theory and Practice (Ann Arbor Science, Michigan).

**Pen, J.**, 1990, Kunnen economen het milieubederf begrijpen?, Hollands Maandblad, 31, nr 5-6, pp. 16-20.

**Schama, S.**, 1987, The Embarrassment of Riches; an Interpretation of Dutch Culture in the Golden Age (Collins, London).

**Schouten, D.B.J.**, 1985, De sociaal-economische doelstellingen en hun ontwikkeling, in C. de Galan et al. (eds.), Economische Orde en Beleid (Kluwer/ SER, Den Haag), pp. 19-33.

**Sociaal Economische Raad**, 1989, Advies over het Rapport "Our Common Future", Publicatie nr. 6 - 17 maart (SER, 's-Gravenhage).

**Vos, J.B. et al.**, 1985, Indicators for the State of the Environment, IvM-VU publication R/85/1 (IvM-VU, Amsterdam).

**Vos, J.B. et al.**, 1986, Vijftien Indicatoren voor de Toestand van het Milieu, IvM-VU publication R/86/5 (IvM-VU, Amsterdam).

### Summary

*The economic debate on the environmental policy needs a clear measure of pollution or "mirror of cleanliness". This environmental index, which summarizes all available data on the state of pollution and environmental damage, is to indicate to what extent the country has been polluted. Such index may be very helpful to the proponents of environmental policy, as it makes the environment a rival of other economic policy problems, such as unemployment, the government deficit, inflation, or disposable income, all of which are summarized in appealing indices or numbers. Moreover, when similar indices are constructed for a number of neighbouring countries, the resulting trade balance of pollution may be instrumental in coordinating environmental policy. The latter is particularly important in the case of small open economies, where pollution is imported to a large extent. This paper discusses the scope for the construction of an appropriate environmental index for the Netherlands and illustrates how it can be used in policy analysis. Some environmental indicators for which time series already are available for the Netherlands are combined to a prototype of a mirror of cleanliness. However, the main lesson from this*

*combination exercise is that we need much better data and more sophisticated combination techniques in order to arrive at an index of practical relevance.*